WatKAN: CREATING A WATER KNOWLEDGE APPLICATION NETWORK
TO ADDRESS CHALLENGES RELATED TO PERMAFROST THAW

WILLIAM QUINTON, WILFRID LAURIER UNIVERSITY

Research conducted 2013-2014

Canadian Water Network

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WHY DID WE DO THIS RESEARCH?

Northeastern British Columbia (NEBC) and the adjacent southern Northwest Territories (NWT) are among the most rapidly warming regions on Earth, and are experiencing unprecedented industrial expansion. There is mounting evidence that warming has affected the border region's water resources. For example, the frequency of mid-winter melt events has increased, end-of winter melt occurs earlier, and key hydrological and climatic variables such as snowpack depth, river discharge, and seasonal precipitation patterns have deviated from long-term means. These changes have brought about dramatic changes to ecosystems with potentially important yet poorly understood feedbacks to hydrological processes and water resources. Recent work in the southern fringe of discontinuous permafrost or "fringe zone", has shown that:

1. the major land cover types each have a unique role in the hydrological cycle;
2. the relative amounts of these cover types and how they are arranged on the landscape is changing due to climate warming, and
3. this warming-induced land-cover change is changing the water balance of drainage basins and the region. The long-term implications of these changes are unclear, and as a result, ecosystem feedbacks affecting the water balance are also poorly understood. This increases the level of risk associated with investments involving water resources.

Linear disturbances (seismic lines, pipe lines, roads) in northeastern BC; these features accelerate permafrost thaw and enhance drainage from the landscape.

Climate warming and human disturbance in the NEBC-NWT border region has led to widespread permafrost thaw and resulting landcover change that has disrupted both the hydrological cycle and the ecosystems and human activities that depend on it. The Water Knowledge Application Network (*WatKAN*), developed as part of this 2013-2014 CWN project, is an essential component of a larger research programme that is focussed on understanding the hydrological changes resulting from permafrost thaw in this border region, developing and mobilising knowledge of these changes, developing predictive modelling tools, and providing interactive training on these tools to our partners in industry, government and communities, including First Nations.

Cover Photo: Scotty Creek, south of Fort Simpson, NWT. Permafrost occurs below the forests, and the treeless areas (wetlands, seismic lines, abandoned winter roads) are permafrost free. Wetlands are expanding laterally due to permafrost thaw.

William Quinton, Wilfrid Laurier University, *Research conducted 2013-2014*

WHAT IS WatKAN?

WatKAN is a regional consortium of industry, provincial, territorial and federal government agencies, NGOs, First Nations and other communities and stakeholders who collaborate to improve the understanding of and ability to predict the impacts of permafrost thaw on their shared water resources. The consortium approach is keenly supported by all participants and is fundamental to *WatKAN*. By contributing knowledge on permafrost thaw impacts to both the BC and NWT water strategies, *WatKAN* improves the scientific basis of the framework within which all water users of the border region will manage their shared resource, and will reduce the uncertainty of water futures by putting customised science-based tools into the hands of trained end-users that will increase their predictive capacity.

Our industrial partners include the Horn River Basin Producers Group (HRBPG) and the Petroleum Technology Alliance of Canada (PTAC). Knowledge of permafrost thaw impacts are important to the petroleum industry because 1) permafrost thaw greatly increases infrastructure construction and maintenance costs by causing pipeline rupture, instability of platforms, cracks in foundations from subsidence, and the nearly constant need for road resurfacing. Activities such as drilling wells, creating borrow pits, water storage ponds and linear features such as winter roads, seismic lines and pipelines, all increase thaw rates by disturbing the insulating surface layer of soil. Permafrost thaw and the resulting landcover change adds uncertainty to the question of how much freshwater will be available in the future in the border region. This uncertainty has a negative effect on industry security. Industry requires both improved capacity to predict future water supplies and mitigation strategies to reduce costs resulting from permafrost thaw.

WatKAN's community partners include the Dehcho First Nation (DFN), the Liidlii Kue First Nation (LKFN) and the Jean-Marie River First Nation (JMRFN). Permafrost thaw is of great concern to aboriginal communities, especially with regard to its impact on the long term health of water resources and natural ecosystems. In particular, unconventional gas extraction by hydraulic fracturing (fracking) has increased dramatically in recent years, and is expected to intensify. Fracking requires such large volumes of water that industrial water use in the border region has put pressure on both ecosystems and public water supplies. However, there is a lack of knowledge on the rates, patterns and impacts of permafrost thaw, and how these factors may change when considering natural feedbacks in the environment. This has prevented researchers from being able to accurately predict the impacts of permafrost thaw on water resources in the future. As a result industry, communities and governments lack the knowledge and predictive tools needed for rigorous, science-based decision making on water resource and ecosystem planning and management, water and land permit approval and environmental impact assessment.

This project also partners with the BC and NWT governments. Both are in the early stages of implementing their water strategies – the Water Sustainability Act in BC and the Water Stewardship Strategy in the NWT. Both governments are committed to consulting with industry, communities and researchers prior to implementing their water strategies. The *WatKAN* team already meets regularly with both governments and will continue with this method of engagement as a means of mobilising water knowledge to those that use it to make decisions, support planning and policy development and create operational procedures, for the benefit of both industry and communities.

TRAINING & EDUCATION:

There is growing need for well-trained professionals to manage, regulate, predict, and study water resources given the growing pressures on this important resource. *WatKAN* is stimulating a community of producers, mobilisers and users of water knowledge and prediction all focussed on the border region. Building a community consortium is fundamental to *WatKAN* and will also provide a rich environment for high-quality training and education.

Training of Students & Technicians: A central goal of *WatKAN* is to produce readily-employable trainees with strong practical and theoretical knowledge developed through field, laboratory, and quantitative training. In consultation with Consortium members and collaborators, training plans were developed for students that permitted them to develop specific expertise as well as advanced practical knowledge in high demand by industry and government. *WatKAN* has provided students with comprehensive training in research planning, execution, analysis, and communication of research in peer reviewed journals, conference presentations, and public engagement programs. As such, *WatKAN* is

1. producing a cohort of water scientists with specialised training to manage, mitigate and predict changes to northern water resources and ecosystems,
2. providing training on critical skills in plain language communication with industry, communities, and government agencies, and in so doing will also facilitate science-based decision making, and
3. providing employers in many sectors (e.g. local communities, industry, environmental consulting, government agencies) with highly-skilled employees with extensive networks on water knowledge, production, mobilisation and use.

Training of professionals: *WatKAN*'s consortium approach and emphasis on collaborative training will nurture a "community of learners" among the BC and NWT governments, industry, local communities, and NGO professionals. *WatKAN* provides interactive training workshops on the application of the predictive tools. This directly benefits water managers involved with implementing BC's Water Sustainability Act and the NWT's Water Stewardship Strategy. These individuals will then have the skills necessary to work directly with industry, NGOs, and communities to apply these predictive tools and extend this training beyond what the *WatKAN* could facilitate. In short, we are "training the trainers," allowing the long-term use of the *WatKAN* predictive toolkit in a more independent way by end user groups. This is highly relevant training as RAVEN is the hydrological model being used by the BC Government and CHRM is being incorporated into the Government of the NWT's (GNWT's) predictive strategy. By integrating the two modelling platforms and by training BC and NWT government users, we will facilitate more consistent predictions in the BC-NWT border region.

CONTRIBUTIONS TO PROJECT PARTNERS:

WatKAN transformed the Cold Regions Hydrological Model (CRHM) and RAVEN into accessible and easy to use predictive tools for government agencies, industry and local communities. This was accomplished by appointing a Community Interface Developer (CID) at the outset of the project, and six-months later, appointing a Community Modeller (CM) responsible for the interactive training of user groups with both models. The CRHM interface is now complete, and several versions were produced to meet the needs of individual user groups. The CM is a GNWT/Environment and Natural Resources (ENR) employee appointed by the Deputy Minister of the ENR to this role for 50% of his time, and to integrate this role into his other ENR duties.

The GNWT is undergoing the process of devolution and as such has taken on new responsibilities, including those for managing the Territory's water resources. Unprecedented climate warming and industrial expansion in the North have led to permafrost thaw, landcover change, and streamflow changes. These changes introduce considerable uncertainty regarding

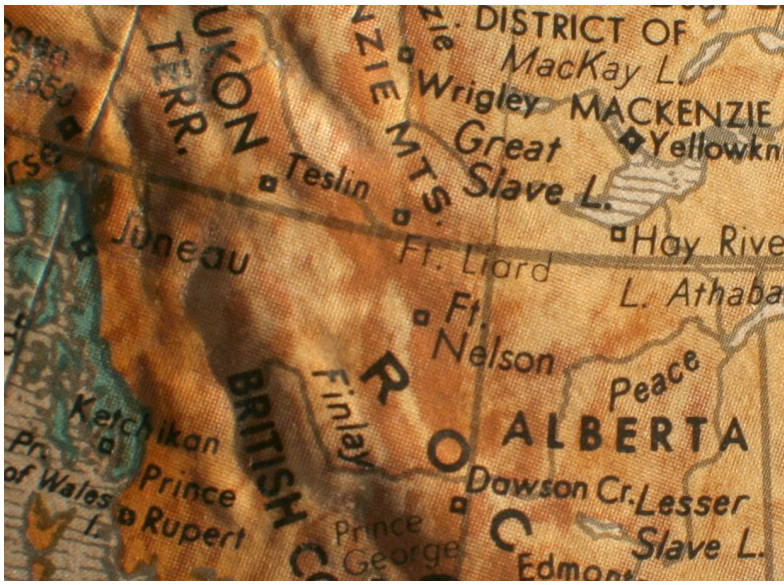
the future availability of northern water resources. The CRHM and RAVEN modelling tools were developed from extensive field observations (since 1999) at sites throughout the NWT, tested and incorporated into the platform with the new interface. These tools have provided the ENR (*WatKAN* Partner) with operational hydrological tools and predictive capacity that they did not have before *WatKAN*. End-users, including aboriginal communities have begun planning the incorporation of the new tools into scenario testing. Their scenario tests evaluate the impacts of earlier snowmelt, greater seasonal ground thaw depths, changes in precipitation distribution (e.g. single day vs. multi-day events) and total amounts of precipitation, changes to landcover (e.g. shrubland, forest, wetland) types on streamflow and other water resource components.

The industry recognises the border region as a data poor, knowledge poor area that is undergoing rapid industrial expansion due to its potential for natural gas production. *WatKAN* provide our industrial partners with a new suite of science-based tools (i.e. conceptual and computational models) to predict the rate and pattern of permafrost thaw and resulting changes in landcover and water supply over the next half-century. Without this predictive capacity, the industry 1) cannot properly mitigate the negative impacts of permafrost thaw on operations, 2) faces the prospect of very high but avoidable costs of damage to infrastructure resulting from permafrost thaw, and 3) cannot confidently plan future operations without knowledge of future water supplies. The new *WatKAN* toolkits are critical to industry for scenario planning on alternative futures involving different degrees of climate warming, human disturbance, resource development, permafrost thaw and land-cover and water supply changes. Better planning and mitigation will also result in reduced environmental impact and therefore better community relations, critical factors as the industry expands operations in the HRB, Cordova, and other proposed northern development areas such as the Liard Basin and the Sahtu (i.e. central Mackenzie) Region of the NWT. *WatKAN* goes beyond the production of new predictive tools, to interactively train the industry on their use at *WatKAN* training workshops and throughout the year through on-going collaboration. As such, the tools will quickly become customised and to suit industry needs. Since the *WatKAN* tools will continue to be developed using RAVEN and CHRM, platforms also being used by the BC and NWT governments, the new tools will assist industry in coordinating scenario and planning exercises with government agencies.

CONTRIBUTIONS TO THE STATE OF KNOWLEDGE IN THE BORDER REGION:

Training on and familiarity with RAVEN and the Cold Regions Hydrological Model (CRHM) has brought to project partners (ENR) and end users (resource managers in aboriginal communities) a new understanding of key environmental processes controlling the flow and storage of water in the area. That is, CRHM has not only increased predictive capacity, but also the ability of water resource managers to diagnose the impacts of changes to hydrological inputs (rainfall, snowmelt) and changes to the water flow and storage processes resulting from changes to the landscape, whether driven by warming (e.g. regional permafrost thaw) or by direct human disturbance (e.g. seismic lines, drill pads, ferry crossings, highways, runways). The new models have also provided new knowledge on how the aforementioned human activities can be implemented with a minimum of impact. For example, the impact of seismic lines is easily diagnosed by varying in CRHM the width of the line, its orientation, and other characteristics.

CONTRIBUTIONS TO CANADA:



Governments across Canada have embraced watershed-based assessment strategies intended to protect water at the source. The success of such strategies depends on a physically- and ecologically-based understanding of, and an ability to model and predict the flux and storage of water. Developing this knowledge and predictive capacity is central to *WatKAN*, and it will become increasingly important to Canadians as pressures on water resources increase throughout the Boreal, and eventually affect all diverse water uses including potable water supply, hydro-electric generation, bulk water exports, industrial water use, recreation, wastewater treatment, etc. Development of Canada's Boreal region is hampered by a lack of ecosystem-based knowledge and predictive capacity. Although difficult to directly quantify, the intrinsic and direct value that Canadians derive from Boreal ecosystems is very large and therefore the costs of not improving our predictive ability is also very large. Our natural resources provide a substantial component of the Canadian economy, with forestry in Boreal regions alone adding $59 billion.

Climate change is one of the most significant challenges to Canada's economic and environmental security. In addition, the Organisation for Economic Co-operation and Development reports that Canada's environmental performance lags behind other G-7 and OECD countries. *WatKAN*'s new predictive tools, coupled with interactive training on their application, is key to incorporating science-based management into northern community, resource and economic development. *WatKAN* is also a long-term investment in Canada's northern water resources through its training of the next generation of Boreal water scientists and managers. A strong role in sustainable development in the north involving science-based prediction models leading to prudent industrial investment and knowledge-based community involvement will be *WatKAN*'s greatest achievement.

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